SYSTEM AND METHOD FOR CONTROLLING HAPTIC DEVICES HAVING MULTIPLE OPERATIONAL MODES

PRIORITY

[0001] This Application claims priority to U.S. Provisional Patent Application No. 60/530,979, file on Dec. 22, 2003, entitled, "System and Method for Controlling Haptic Devices Having Multiple Operational Modes," the entire disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] The invention relates generally to haptic feedback devices. More specifically, the invention relates to controlling haptic devices each having multiple operational modes.

[0003] Computer users often use interface devices to provide information to computers or other electronic devices. For example, with such interface devices, a user can interact with an environment displayed by a computer to perform functions and tasks on the computer, such as playing a game, experiencing a simulation or virtual reality environment, using a computer aided design system, operating a graphical user interface (GUI), or otherwise affecting processes or images depicted on an output device of the computer. Common human interface devices for computers or electronic devices include, for example, a joystick, button, mouse, trackball, knob, steering wheel, stylus, tablet, pressure-sensitive ball, remote control, wireless phone, and stereo controls.

[0004] In some interface devices, feedback, such as force feedback, can also be provided to a user. Each of these interface devices, for example, includes one or more haptic devices, which are connected to a controlling processor and/or computer. Consequently, by a controlling processor, controller, and/or computer, haptic forces produced by the haptic device can be controlled in coordination with actions of the user and/or events associated with an audible environment or a graphical or displayed environment by sending control signals or commands to haptic feedback device.

[0005] Multi-mode haptic devices that provide desirable performance have been developed. For example, U.S. application Ser. No. 10/301,809, entitled, "Haptic Feedback Using Rotary Harmonic Moving Mass," the entire disclosure of which is incorporated herein by reference, discloses haptic feedback using a device having a rotary harmonic moving mass. Accordingly, additional systems and methods for controlling multi-mode haptic devices are desirable.

SUMMARY

[0006] An embodiment of the invention provides a system and method for controlling multi-mode haptic devices. A haptic device having multiple operational modes, including a first operational mode and a second operational mode is provided. The first operational mode is associated with a frequency range. The second operational mode is associated with a frequency range that is different from the frequency range of the first operational mode. A controller is coupled to the haptic device, and is configured to send the haptic device multiple control schemes. Each control scheme is uniquely associated with an operational mode from the multiple operational modes. According to an embodiment of the invention, the controller is configured to combine each control scheme from the multiple control schemes prior to sending the multiple control schemes to the haptic device.

[0007] Another embodiment of the invention provides a method that uses a voltage pulse to reduce the response time of a device. According to this method, steady-state power is provided to a haptic device that is configured to cause the haptic device to output a haptic sensation above a pre-determined sensation threshold. A voltage pulse, which is configured to change the haptic sensation output by the haptic device by a pre-determined amount within a pre-determined, reduced response time, is applied to the haptic device. According to an embodiment of the invention, the voltage pulse is applied to the haptic device prior to providing the steady-state power to the haptic device. According to another embodiment, the voltage pulse is applied to the haptic device after terminating the steady-state power provided to the haptic device. The voltage pulse can be applied to a single-mode haptic device or a multi-mode haptic device. According to one or more embodiments of the invention, use of such a voltage pulse can improve response time of a haptic device to which the pulse is applied (e.g., for stopping or starting haptic effects, etc.).

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** is a block diagram of a system including a processor system and an interface device, according to an embodiment of the invention.

[0009] **FIG. 2A** is a diagram illustrating a haptic device, a controller, and a sensor, according to an embodiment of the invention.

[0010] **FIG. 2B** is a block diagram of a haptic device, according to an embodiment of the invention.

[0011] **FIG. 3A** is a perspective view of a haptic device, according to an embodiment of the invention.

[0012] **FIG. 3B** is a cross-sectional view of the haptic device shown in **FIG. 3A**.

[0013] **FIG. 4A** is a perspective view of a haptic device, according to an embodiment of the invention.

[0014] **FIG. 4B** is a cross-sectional view of the haptic device shown in **FIG. 4A**.

[0015] **FIG. 5** shows a top view of a portion of a haptic device, according to an embodiment of the invention.

[0016] **FIG. 6** shows a top view of a portion of a haptic device, according to an embodiment of the invention.

[0017] **FIG. 7** shows a top view of a portion of a haptic device, according to an embodiment of the invention.

[0018] **FIG. 8** is a plot showing an acceleration-versus-time response of a haptic device, according to an embodiment of the invention.

[0019] **FIG. 9** is a plot showing an acceleration-versus-time response of a haptic device, according to an embodiment of the invention.

[0020] **FIG. 10** is a plot showing drive-signal frequency ranges of a multi-mode haptic device, according to an embodiment of the invention.